1967

Effects of Different Exercise Programs on the Development of Cardiovascular Fitness, Strength and Muscular Endurance.

Daniel P. Mcnair
Louisiana State University and Agricultural & Mechanical College

67-17,335

McNAIR, Daniel P., 1930-

EFFECTS OF DIFFERENT EXERCISE PROGRAMS ON THE DEVELOPMENT OF CARDIOVASCULAR FITNESS, STRENGTH AND MUSCULAR ENDURANCE.

Louisiana State University and Agricultural and Mechanical College, Ph.D., 1967
Education, physical

University Microfilms, Inc., Ann Arbor, Michigan

EFFECTS OF DIFFERENT EXERCISE PROGRAMS ON THE DEVELOPMENT OF CARDIOVASCULAR FITNESS, STRENGTH AND MUSCULAR ENDURANCE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Health, Physical and Recreation Education

by
Daniel P. McNair
B.S., Auburn University, 1953
M.Ed., Auburn University, 1959
August, 1967

ACKNOWLEDGMENTS

The author wishes to express appreciation to his major professor, Dr. Jack K. Nelson, for his helpful assistance in conducting this study.

Special recognition is extended to the faculty and students of Pembroke State College in Pembroke, North Carolina for their effort and cooperation.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

APPENDIX PAGE

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

It was the purpose of this study to determine the effects of three exercise routines of short duration, given in conjunction with a regular physical education program, on the development of cardiovascular fitness, leg strength, and muscular endurance of the legs of a selected group of college males.

One hundred twenty male students at Pembroke State College, Pembroke, North Carolina served as subjects for this study. The subjects were divided into four groups: Group I performed a five-minute interval run in addition to the regular required program of physical education; Group II performed a specially designed stepping exercise of two and one-half minutes duration along with the physical education activity; Group III performed a program of four isometric exercises for a period of eight seconds for each exercise in addition to the physical education program; and Group IV, the control group, participated only in the regular required program of physical education. All subjects took part in the same physical education activities, consisting of soccer, touch football, basketball, and wrestling. The first week of the experiment was devoted to orientation and pre-test training to familiarize the subjects with the tests and their administration. All groups were tested the following week in order to establish the initial scores on the variables involved in the study. The subjects then trained three days a week for six weeks.

At the end of the six-week training period, all subjects were re-tested in an effort to determine whether or not significant changes in cardio-vascular fitness, leg strength, and muscular endurance of the legs occurred during the study.

The *t*-test was used to determine the significance of the gains made between the initial and final tests of cardio-vascular fitness, leg strength, and muscular endurance of the legs. Analysis of variance was utilized to determine if there were significant differences among the four groups in the mean gains made in each of the variables.

The findings of this study were as follows:

1. The gains made in cardio-vascular fitness by all four groups were significant at the .01 level of probability. No significant differences were found among the four groups in cardio-vascular fitness gains.
2. All four groups showed significant improvement in leg strength after six weeks of training. The gains were significant at the .01 level of probability. When the groups were compared, no significant differences in leg strength gains were found.
3. The gains made in muscular endurance scores were significant at the .01 level of probability for all four groups. No significant differences existed among the four groups in the amount of improvement made in muscular endurance scores.

Within the limits of this study, it was concluded that significant gains in cardio-vascular fitness, strength and endurance can be brought about by placing the individual under sufficient stress. The nature of the conditioning program is not the important consideration as long as it is sufficiently strenuous.

CHAPTER I

INTRODUCTION

It has been stated that "the key to the development of stamina appears to be work, work, and more work with progressively increased loads."[1] Stamina for running has been thought of as a long-term development that is only acquired as a result of long hours of running. This approach to physical education in the past has been somewhat masochistic in nature. To push oneself to the limit, or at least to the point where one feels he can go no further is more or less the accepted method of training by many coaches and athletes in the field. There is no logical reason why training for a strenuous activity should be unpleasant. The fact that one tends to repeat the actions that are enjoyed and to shun unpleasant experiences would, in itself, justify exploration in this area.

Although it may be desirable to attain the highest possible degree of physical fitness, to push oneself beyond the point where maximum efficiency is realized is not only a waste of time, but it also takes much of the enjoyment out of the activity. Persons involved with the training and conditioning of athletes are well aware of the

---

[1]Philip J. Rasch, "Endurance Training for Athletes," Journal of the Association for Physical and Mental Rehabilitation, XIII (November-December, 1959), 185.

problem of sustaining enthusiasm and interest of the subjects over a long period of time.

Much of the information concerning training methods now in use has been primarily the result of years of trial and error by athletic coaches. Lately, as a result of research, many of the older methods of conditioning are now obsolete. Several investigators have found evidence that other forms of exercise can be as effective, if not more so, than the traditional program of running and more running. Research by Howell and others[2] led them to surmise that isometric and isotonic exercises were equally effective in increasing muscular endurance. A subsequent study by Alost[3] showed no significant difference between programs of running and isometric exercises in the development of cardio-vascular fitness. Although considerable progress has been made in the improvement of physical conditioning more definite scientific knowledge is needed about the actual physical changes brought about through different training methods.

One objective of a good training program is to attain the maximum amount of physical efficiency in the minimum amount of time. Coaches and physical educators are constantly faced with the problem

---

[2]Maxwell L. Howell, Ray Kimoto, and W. R. Marford, "Effects of Isometric and Isotonic Exercise Programs Upon Muscular Endurance," Research Quarterly, XXXIII (December, 1962), 536-540.

[3]Robert Alost, "Effects of Initial Cardio-Vascular Condition, Type of Training Program, and Frequency of Practice Upon Cardio-Vascular Development," 67th Proceedings of the National Physical Education Association for Men, (1964), p. 25.

of having their charges attain a satisfactory degree of physical condition in a limited amount of time. Research on training methods should aid the physical educator and athletic coach in organizing effective programs.

This study was undertaken to investigate the effects of short bouts of intensive exercises given in conjunction with a regular physical education program on the development of selected measures of physical condition.

I. PURPOSE OF THE STUDY

It was the purpose of this study to determine the effects of three exercise routines of short duration, given in conjunction with a regular physical education activity program, on the development of cardio-vascular fitness, leg strength and relative muscular endurance. The three exercise programs consisted of a five-minute interval run, a $2\frac{1}{2}$-minute bench stepping exercise, and an isometric exercise regime of four, eight-second contractions.

II. LIMITATIONS OF THE STUDY

This study was limited to a period of nine weeks. The first week was devoted to orientation and pre-test training, the second and ninth weeks were utilized for testing; consequently, six weeks were spent in the actual training and physical education activities.

This study was limited to 120 freshman male students enrolled in physical education classes at Pembroke State College.

Each training method used in this study was limited to a five minute time period at the beginning of each class period.

During inclement weather it was necessary for the running group to train indoors on the gymnasium floor. As this resulted in a somewhat overcrowded area in which to run the distance covered and the pace were considerably less than that obtained out-of-doors.

Further limitations were that only one test of each of the three variables was used. Leg strength development was measured in only one position.

III. BASIC ASSUMPTIONS

The subjects were assumed to have been equally motivated and to have performed to the best of their ability during the testing periods and in the class activities.

While there was no actual control of the outside activities of the subjects which might influence the results of the study, they were requested to refrain from additional exercises, and it was assumed that these activities were limited and controlled.

IV. DEFINITION OF TERMS USED

Isometric contraction. Development of tension without a shortening of the muscle fiber.[4]

---

[4]Laurence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise (St. Louis: The C. V. Mosby Company, 1959), p. 27.

Functional isometric contraction. An isometric contraction in the position in which the muscle is to be used.[5]

Leg strength. The ability of the extensors of legs to exert force against resistance.

Muscular endurance. The ability to continue muscular work at a sub-maximal level that makes relatively small demands on the cardio-vascular system.[6]

Relative muscular endurance. The ability to continue muscular work in moving an amount of weight which is a specific proportion of the maximum strength of the muscles to be utilized.

Cardio-vascular fitness. The strength and endurance of the heart and efficiency of the circulatory system in adjusting to work situations.[7]

---

[5]Robert Hoffman and others, Functional Isometric Contraction for Football (New York: Bob Hoffman Foundation, 1962), p. 9.

[6]Rasch, op. cit., p. 183.

[7]Carlton R. Meyers and T. Erwin Blesh, Measurement in Physical Education (New York: Ronald Press Company, 1962), p. 177.

CHAPTER II

REVIEW OF RELATED LITERATURE

The related literature for this study has been divided into two major categories: (1) literature of a general nature concerning cardio-vascular fitness and endurance, and (2) studies pertaining to the effects of training on cardio-vascular fitness, strength, and endurance.

I. LITERATURE OF A GENERAL NATURE CONCERNING CARDIO-VASCULAR FITNESS AND ENDURANCE

Karpovich[1] stated that endurance may be thought of in terms of how long a certain exercise can be maintained, and in many cases this exercise involves a repetition of a certain movement, thus giving a criterion by which comparisons can be made. He further stated that the state of fatigue in a person determines the limit of endurance and therefore all the factors which delay the onset of fatigue in a person determine the limit of endurance and therefore all the factors which delay the onset of fatigue also increase the endurance.

Steinhaus[2] stressed the importance of distinguishing between muscular endurance and circulo-respiratory endurance. He pointed out

---

[1]Peter V. Karpovich, "Fatigue and Endurance," Research Quarterly, XII Supplement (May, 1941), 416-422.

[2]Arthur H. Steinhaus, Toward an Understanding of Health and Physical Education (Dubuque: William C. Brown Company, 1963), p. 60.

that all forms of endurance are dependent upon circulation; however, muscular endurance, which means lifting the same weight many times, is also related to strength. When a muscle is strong enough to perform a task by using only one-third of its motor units, then two-thirds are resting. Those muscles that are not working shut off their own blood supply. After a period of time another group of muscles takes over and permits the previously active ones to rest. Thus, by rotating units the activity can be kept up much longer and therefore a stronger muscle can hold a given tension much longer than a weak one. Ischemia, or the muscular pain due to fatigue, is caused by a shortage of blood supply. A man must endure some of this pain whenever he is pushing himself to the limit of his endurance.

In an article reviewing literature pertaining to endurance training for athletes, Rasch[3] suggested that there are three ways in which this factor can be developed: (1) by increasing the efficiency of movement, thereby reducing the energy expenditure required to perform a given task, (2) by increasing the rate at which oxygen can be taken up and transported to the muscles, and (3) by developing the ability to ignore the discomforts associated with fatigue and oxygen debt.

Rasch found that there are four main theories of training for

---

[3]Philip J. Rasch, "Endurance Training for Athletes," Journal of the Association for Physical and Mental Rehabilitation, XIII (November-December, 1959), 182-185.

endurance at the present time--fartlek training, circuit training, interval training, and repetition training.

Fartlek is a Swedish word which may be freely translated as "speed play." Morehouse and Rasch[4] have written that this type of training attempts to provide a program which is similar to a natural pattern of activity. It is begun by having those participating engage in easy cross country running. After the runners have become accustomed to easy cross country running, untimed variations of pace are introduced into the program. These variations range from short, sharp, sprints to sustained efforts over longer distances. The daily training program is planned over a given period of time rather than a given distance.

The assumptions underlying circuit training, as described by Rasch,[5] are that general fitness is determined by the following qualities: muscular strength, or the ability to exert force against resistance, muscular endurance, or the ability to continue muscular work at a sub-maximal level that makes relatively small demands on the cardio-vascular system, general endurance, or the ability to continue performance that places relatively large demands on the cardio-vascular system, and muscular power. It is further assumed that there must be a progressively increased loading of the

---

[4]Lawrence E. Morehouse and Philip J. Rasch, Sports Medicine for Trainers (Philadelphia: W. B. Saunders Company, 1963), p. 115.

[5]Rasch, op. cit., p. 185.

cardio-vascular system over long periods if general endurance is to be developed. Circuit training usually consists of progressing from one exercise station to another with each station containing exercises which are designed to develop certain areas of general fitness. The person moves from station to station until a complete "circuit" is made.

Smodlaka[6] pointed out that the principle underlying interval training is that there are many short periods of work and rest. Each period of work is followed by rest to enable the heart and body to recuperate.

Morehouse and Rasch[7] described interval training in practice as a series of distances to be run on a previously planned schedule. A fast lap is followed by a slower, or interval, lap to permit recovery before a subsequent fast lap. In the beginning of training the recovery lap may be three times longer than the fast lap. As training progresses, the recovery time is shortened.

Rasch[8] described repetition training as consisting of running a given distance a certain number of times, at a given speed with a complete rest between runs. He stressed that the rest must be long enough to permit the participant to recover sufficiently in order

---

[6]Vojin Smodlaka, "Interval Training in Heart Disease," The Journal of Sports Medicine and Physical Fitness, III (June-Sept., 1963), 93-100.

[7]Morehouse and Rasch, op. cit., p. 115.

[8]Rasch, op. cit., p. 185.

to make the next set of repetitions at the predetermined speed. Scott and Crofts[9] stated that repetition training is slightly more demanding than interval training and is most helpful in developing speed and endurance.

II. STUDIES PERTAINING TO THE EFFECTS OF TRAINING ON CARDIO-VASCULAR FITNESS, STRENGTH, AND ENDURANCE

During recent years there has been considerable interest shown in isometric exercise as a means of physical development by those in physical education, athletics, and the medical profession. Numerous research studies have indicated that isometrics will develop strength and more recently it has been found that cardio-vascular fitness is also improved. This review of literature did not attempt to cover the material available on isometric research in great detail but rather to review studies relating closely to this study. For a more complete review of the progress in the field of isometrics the reader is referred to "Isometric Exercises," by Philip J. Rasch.[10]

Although it has been known for some time that isometric contractions produce an increase in strength, it remained for

---

[9]Phebe M. Scott and Virginia R. Crofts, Track and Field for Girls and Women (New York: Appleton-Century-Crofts, 1964),

[10]Philip J. Rasch, "Isometric Exercises," International Research in Sport and Physical Education, Edited by E. Jokl and E. Simon, (Springfield, Mass.: Charles C. Thomas Company, 1964), pp. 415-428.

Hettinger and Muller[11] to re-open this approach to training. In their research they found that a single two-thirds maximum isometric effort for six seconds a day resulted in a weekly gain of 5 per cent of the initial strength, although increases in frequency, duration, or amount of effort did not result in faster or greater improvement. However, a subsequent study by Muller and Rohmert[12] indicated serious errors in the original work of Hettinger and Muller. Their work revealed that the rate of strength gain approximately doubled when maximal contraction strength can be reached by increasing the number of contractions.

The effects of short bouts of isometric and isotonic contractions on muscular strength and endurance was studied by Walters, et al.[13] in an experiment utilizing fifteen subjects. The subjects were divided into three groups, using full isometric strength, two-thirds isometric strength, and the last group using one-third isotonic strength as rapidly as possible. The training period was confined to three 15-second

---

[11]Thomas Hettinger and E. A. Muller, "Muskelleistrung and Muskeltraining," Arbeitsphysiologie, XV (1953), 111-126. Quoted in International Research in Sport and Physical Education. Edited by E. Jokl and E. Simon, (Springfield: Charles C. Thomas Company, 1964), p. 415.

[12]E. A. Muller and W. Rohmert, "Die Geschwindigkeit der Muskelkraft Zunahme bei Isometrischen Training," Int. Z. Agnew Physiol. einschl Arbeitsphysiologie, 19:403-19, 1964. Cited in deVries, Herbert, Physiology of Exercise (Dubuque: William C. Brown, 1966), p. 308.

[13]C. E. Walters, C. L. Stewart, and J. F. LeClaire, "Effect of Short Bouts of Isometric and Isotonic Contractions in Muscular Strength and Endurance," American Journal of Physical Medicine, XXXIX (August, 1960), 131-141.

periods for eight days. The experimenter found that full isometric contraction was the more effective of the three methods used. The group using two-thirds isometric contraction made about the same gains as the isotonic group. Endurance as measured by the maximum number of isotonic repetitions possible was improved in all groups, but most markedly in the full isometric group. The improvement shown in all groups was not only retained when retested at three and eight weeks after training had ceased but had increased further.

Howell and others[14] compared the effectiveness of an isometric exercise program and a regular isotonic exercise program of weight lifting upon muscular endurance as measured by two minutes of "all out" work on a bicycle ergometer. At the conclusion of the experiment the writers found that both groups made significant gains in muscular endurance. However, there was no significant difference between the means of the two experimental groups. The writers, therefore, hypothesized that increases in muscular endurance may be affected by certain programs of isometric contraction as well as by isotonic exercises.

Thirty-one subjects divided into two groups were utilized by Marley[15] to compare the gains in strength and endurance resulting from

---

[14]Maxwell Howell, Ray Kimoto and W. R. Morford, "Effects of Isometric and Isotonic Exercise Programs upon Muscular Endurance," Research Quarterly, XXXIII (December, 1962), 536-540.

[15]William P. Marley, "The Comparative Effectiveness of Isometric Exercise and Isotonic Exercise in the Development of Muscular Strength, Endurance and Girth" (unpublished Master's thesis, University of Maryland, 1962), p. 70.

isometric and isotonic training programs. He concluded that there is little difference in the effectiveness of either program in the development of strength. Endurance was found to be more specific in that each type of training was more effective in producing that type of endurance, i.e., isotonic training produced isotonic endurance.

Alost[16] studied the effect of initial cardio-vascular condition, type of training program, and frequency of training upon the gain in the Harvard Step Test scores of college men. The experimenter also made an effort to determine the effects of the various training programs upon proficiency in the activity engaged in during the study. Two hundred forty students at Louisiana State University served as subjects for this study and were divided into three groups. One group performed isometric exercises and the other two groups participated in a program of running. The subjects were tested prior to and immediately after the training period. The results indicated that there was no significant difference between the effectiveness of an isometric program and a running program in the development of cardio-vascular fitness as measured in this study. Individuals of low cardio-vascular fitness tended to gain more rapidly than those more fit; however, those below par students were not able to reach the level of the above average group. Improvement in cardio-vascular condition was in proportion to the frequency of practice.

---

[16]Robert A. Alost, "Effects of Initial Cardio-Vascular Condition, Type of Training Program, and Frequency of Practice upon Cardio-Vascular Development," Proceedings of the National Physical Education Association for Men, (1964), p. 29.

Wallace[17] assigned thirty-three college women to three groups--an isotonic exercise group, an isometric exercise group, and a control group. Retesting after four weeks of training showed no significant difference in elbow flexion strength. However, the isotonic exercise group showed increased endurance significant at the .01 level, the isometric group showed increased endurance significant at the .05 level, and the control group showed no change.

Milton[18] studied the effectiveness of three training programs of distance running and a program of isometric exercises upon the development of cardio-vascular efficiency of 469 college men. The three running groups ran for ten minutes, twenty minutes, and thirty minutes, four times a week for a period of seven weeks. A fourth group engaged in isometric exercises for thirty minutes. The results of the study led the investigator to conclude that all four training programs resulted in significant improvement of cardio-vascular efficiency. Generally, distance running was found to be more effective in bringing about improvement in cardio-vascular efficiency than isometric exercise.

---

[17]Joseph Wallace, "The Development of Muscular Strength and Muscular Endurance Through Isotonic and Isometric Exercise," New Zealand Journal of Physical Education, 14:33-39, April, 1958. Cited in International Research in Sport and Physical Education. Edited by E. Jokl and E. Simon (Springfield: Charles C. Thomas, 1964), p. 417.

[18]George C. Milton, "The Effects of Three Programs of Long Distance Running and an Isometric Exercise Program on the Development of Cardio-vascular Efficiency" (unpublished Doctoral dissertation, Louisiana State University, Baton Rouge, 1966).

Freeman[19] attempted to determine whether or not training altered the methods of oxygen transport during mild to moderately severe exercise. This study utilized cardiac catheterization, various respiratory function tests, and (for one subject) a vigorous step-test exercise, to investigate the cardiac-respiratory effects of training on athletes. The observations in the study were made on three distance runners. No differences attributable to training were seen in the way a trained or untrained athlete meets the tissue demands for an increased supply of oxygen during exercise up to levels requiring about two liters of oxygen intake per minute.

Kirby[20] tested one hundred forty college men on cardio-vascular efficiency and several physical fitness items, then divided the subjects into five experimental groups. All subjects were participating in physical education activities in addition to performing their assigned exercise program. One group engaged in only one isometric exercise; the next group performed the isometric exercise and ran in place; the third group performed these two exercises and a jumping exercise; the fourth group practiced the aforementioned exercises and push-ups; and the fifth group engaged in calisthenics the entire period.

---

[19] M. E. Freeman and others, "Effects of Training on Response of Cardiac Output to Muscular Exercise in Athletes," Journal of Applied Physiology, VIII (July, 1955), 37-47.

[20] Ronald F. Kirby, "The Effects of Various Exercise Programs Involving Different Amounts of Exercise on the Development of Certain Components of Physical Fitness" (unpublished Doctoral dissertation, Louisiana State University, Baton Rouge, 1966).

The findings indicated that on the total fitness battery, the subjects doing the least number of supplementary exercises made the most improvement. It was thus hypothesized that it was intensity of effort rather than time spent exercising, or the number of repetitions or number of exercises that was the important factor in conditioning.

Four specific programs of interval running were studied by Mole[21] to observe their influence on aerobic metabolic function and endurance performance upon four young male university students. The training programs were evaluated in terms of oxygen debt, rate of oxygen debt, and oxygen requirements as well as endurance performance. The writer concluded that:

1. Physiological adaptations to the training, as reflected in peak oxygen intake, occurred more readily in programs emphasizing repetition of a set schedule than in those programs alternating test time and pace factors.
2. Endurance performance appeared to be dependent upon other variables as well as aerobic metabolic function since improvement in performance occurred with and without improvement in peak oxygen intake.
3. There may be a relationship between circulatory and respiratory adaptations and total work output during a session of interval running.

---

[21]Paul Angelo Mole, "The Influence of Interval Running on the Aerobic Metabolism and Endurance Performance of Four Young Men" (unpublished Master's thesis, University of Illinois, Urbana, 1960.

Taylor[22] utilized sixty-three subjects in a study to determine the effects of a circuit training program and a calisthenics program on cardio-vascular fitness and muscular strength. Both experimental groups showed gains in performance that were significant at the .01 level for cardio-vascular fitness and muscular strength. The writer concluded that both methods were equally effective in producing improvement in the cardio-vascular and muscular status of businessmen.

Fifteen subjects participated in a study undertaken by Zeigler[23] to determine the optimum frequency of maximum effort exercises for the development of endurance. Three groups exercised once a week, twice a week, and three times a week, for a total of eighteen weeks. The writer concluded that even though all groups made significant increases in endurance, the greatest gain was made by the group exercising twice a week.

In a study investigating effects of hand grip strength and endurance improvement on blood flow, Vanderfog and others[24] found that those subjects participating in the strength training program made significant gains in strength but not in endurance, while those

---

[22]Bruce Malcolm Taylor, "The Effects of Certain Fitness Programs upon the Cardio-Vascular and Muscular Status of Businessmen" (unpublished Master's thesis, University of British Columbia, 1961).

[23]Robert G. Zeigler, "The Frequency of Maximum Effort Most Favorable for the Development of Endurance in College Students" (unpublished Master's thesis, Pennsylvania State University, 1960).

[24]Ellen R. Vanderfog and others, "Effects of Muscle Strength and Endurance on Blood Flow," Journal of Applied Physiology, XVI (September, 1961), 873.

subjects who trained for endurance improved in both endurance and strength.

Scannell[25] conducted a study to show how successfully a new kind of endurance could be maintained by means of "all out" workouts once every week and once every two weeks. Forty-nine subjects trained for twelve training periods spaced over a period of five weeks. The subjects were tested prior to and immediately following the training period. All training work was done on the bicycle which was set with a constant tension of thirty-eight pounds on the brake belt. The exercise was performed at the rate of 160 pedal strokes per minute in cadence with a metronome. After the initial testing and training, one group of subjects exercised on the bicycle once every week, one group exercised every two weeks, and the third group acted as a control group.

The results of this study indicated that it was possible to make large gains in endurance through a relatively small number of "all out" bouts of exercise. Also, the results of the final tests given after the last ten week period, showed that there was a tendency for those subjects who made the greatest gains in the training period to retain the smallest percentage of the gains.

After conducting repeated tests for physical efficiency of

---

[25]Robert James Scannell, "Selected Factors Concerned with the Maintenance of Endurance" (microcarded Master's thesis, Pennsylvania State University, 1959).

seven men during a twelve week period, Cogswell and others[26] made the following observations in relation to the data obtained from the Harvard Step Test, the treadmill set at a ten degree grade and a speed of six miles per hour, and the bicycle ergometer adjusted to individual capacity:

1. In sub-maximal exercise, post-exercise pulse rates showed a decrease with training, whereas maximal tests failed to produce a similar response.
2. Systolic blood pressure, at rest and after exercise, tended to decrease with training on the step test.
3. Men having higher than average resting pulse rates tended to have higher than average post-exercise rates.

III. SUMMARY OF RELATED STUDIES

Section I of this chapter was concerned with literature of a general nature relating to training for cardio-vascular fitness and endurance. The majority of this material indicated a general agreement relative to the nature of endurance, the continued repetition of a certain exercise and the ability to ignore the resultant discomforts for a long period of time.[27]

---

[26]Robert C. Cogswell and others, "Some Observations of the Effects of Training on Pulse Rate, Blood Pressure, and Endurance in Humans, Using the Step Test (Harvard), Treadmill, and Electro-Dynamic Brake Bicycle Ergometer," The American Journal of Physiology, CXLVI (1946), 429.

[27]Karpovich, Steinhaus, and Rasch, loc. cit.

A review of current training methods by Rasch[28] revealed that there are four types of training in wide use at the present time: interval training, repetition training, circuit training, and fartlek training.

Section II was concerned with studies related to the effects of training on cardio-vascular fitness, strength, and endurance. In one study it was found that interval training, emphasizing a set schedule and repetition, resulted in a significant gain in cardio-vascular fitness over programs alternating rest time and pace factors.[29] Another study revealed that a circuit training program and a program of calisthenics were equally effective in producing an improvement in cardio-vascular and muscular status of businessmen.[30] Kirby's[31] results suggested that intensity of a few exercises, given in conjunction with regular physical education activity, was more important than mere number of exercises prescribed in a training program.

There is a vast amount of literature on the effects of isometric exercises. There is consensus that these exercises will bring about significant improvement in strength, however there have been conflicting findings as to the amount of contraction required to produce maximum strength gains.[32]

---

[28]Rasch, loc. cit. [29]Mole, loc. cit. [30]Taylor, loc. cit.

[31]Kirby, loc. cit.

[32]Hettinger and Muller, Muller and Rhomert, Walters and others, loc. cit.

Three studies in this section reported that isometric and isotonic training programs produced equally significant gains in strength.[33] Three studies indicated that isometric and isotonic training programs both resulted in a significant increase in isotonic muscular endurance,[34] while one investigator concluded that endurance was specific to the type of training employed.[35]

One study indicated that there was no significant difference between a program of isometric exercises and a running program in producing cardio-vascular fitness.[36] Milton,[37] however, concluded that a program of distance running was generally more effective than isometric training in producing gains in cardio-vascular fitness. One study revealed that individuals of low cardio-vascular fitness tended to gain more rapidly in this variable through training than those more fit, however, they were not able to reach the level of the above average group.[38] Another study indicated that those making the greatest gains in muscular endurance through training tended to retain the smallest percentage of these gains.[39]

Training by repeated step tests was found by one investigator to have a lowering effect on the systolic blood pressure, as well as the resting pulse rate.[40] Two studies revealed that a relatively small

---

[33]Walters and others, Howell and others, Marley, loc. cit.

[34]Walters and others, Howell and others, Wallace, loc. cit.

[35]Marley, loc. cit. [36]Alost, loc. cit. [37]Milton, loc. cit.

[38]Alost, loc. cit. [39]Scannell, loc. cit. [40]Cogswell, loc. cit.

number of workouts was necessary to reach and maintain increases in endurance.[41]

In summary, there is general agreement that specific training by various methods such as interval training, isometric exercises and repetition training will produce gains in cardio-vascular efficiency, muscular strength and endurance. However, there is very little evidence concerning the comparative effects of interval running, repetitive stepping and isometric exercises when added as short bouts of exercise to a regular training program.

---

[41] Zeigler, Scannell, loc. cit.

CHAPTER III

PROCEDURES OF THE STUDY

I. OVERVIEW OF THE STUDY

Prior to the initial testing of the variables involved in this study a period of one week, or three class periods, was utilized to familiarize the subjects with the purpose of the study and for pre-test training. During the second week of the experiment all subjects were measured for cardio-vascular fitness, leg strength, and muscular endurance of the legs.

The subjects were then assigned to four groups as follows: one group participated in a five-minute interval running program; one group performed a stepping exercise for two and one-half minutes; a third group engaged in a program of isometric exercises; and the fourth group served as a control group. All subjects participated in the regularly designated physical education activities of soccer, touch football, basketball, and wrestling in addition to their respective training programs. At the end of the six-week training period, all subjects were re-tested in order to determine the effects of the various experimental programs on the variables.

II. SUBJECTS

The subjects for this study were 120 college students at

Pembroke State College, Pembroke, North Carolina, ranging in age from seventeen to twenty-one years. The subjects were enrolled in the basic physical education classes in the Department of Health and Physical Education. The basic program for the fall semester consisted of instruction and limited competition in the following activities: soccer, touch football, basketball, and wrestling. All subjects participated in these activities in addition to their respective experimental training program. Although there were some varsity athletes in each class section, they were excluded from participation in the experiment as they were thought to be more highly trained than the non-athletes and perhaps would affect the results. Four different physical education classes were utilized; three classes served as experimental groups with the fourth class comprising the control group. The training programs for the four groups are described in detail later in this chapter. The four groups were identified as follows:

Group I. The subjects in this group participated in a five-minute interval run consisting of alternate jogging and running.

Group II. The training program for this group consisted of a specially designed stepping exercise which consisted of stepping on and off a bench at various speeds for a period of two and one-half minutes.

Group III. The subjects assigned to this group participated in an isometric program which consisted of four leg exercises which were

felt to be functional insofar as the variables of the study were concerned.

Group IV. The subjects in this group served as a control group and were not assigned any form of specialized training, but merely participated in the regular program of physical education activities.

All students taking part in the study were asked to refrain from any physical training programs other than that performed in class.

III. TESTING EQUIPMENT

Step bench. A specially constructed bench, made in three parts, twenty inches high, twenty-four inches wide, and twenty-four feet long was used for the Harvard Step Test and also for training purposes.

Stop watch.[1] A Huer seven-jewel stop watch with a thirty second face and cumulative count dial was used for timing isometric exercises, the running program, the Harvard Step Test, and the special step training program.

Tape recorder.[2] A Columbia model 946 monaural tape recorder was employed to provide standardized cadence in the Harvard Step Test and for the step training method.

Goniometer. A device consisting of two arms permanently set at an angle of 100 degrees was made to insure accurate measurement of

---

[1] Huer Manufacturing Company, distributed by Wolverine Sporting Goods Company, Ann Arbor, Michigan.

[2] Columbia Manufacturing Company, New York, New York.

the angle of knee flexion involved in the tests of leg strength and muscular endurance of the legs.

Testing bench. A special bench designed as a platform for the test of leg strength and for the test of muscular endurance of the legs was constructed.

Iso-scale.[3] The iso-scale was employed to measure the amount of force exerted by the leg extension action of the subject in the testing of leg strength. The iso-scale was attached at one end by means of a short strap affixed to an aluminum mounting plate on the testing bench, while another short strap approximately eight inches in length was attached to the other end of the iso-scale. A webbing belt and steel shaft were used in conjunction with the other equipment to form a harness against which the subject exerted force. The scale on the instrument measures from 0-730 pounds in ten pound increments. In addition to the dial hand, there was a memory pointer that remained in place after recording the highest reading.

Barbell and weights. A standard Healthways barbell, one and one-eighth inches in diameter and five feet long, with a sufficient supply of weights, was used in the test of muscular endurance of the legs. The weights were also used in the calibration of the iso-scales.

Testing belt and chains. A belt of heavy harness leather padded with foam rubber was used for muscular endurance of the legs.

---

[3]Iso-scale, Coach's Sporting Goods Corporation, Marion, Indiana.

Two lengths of chain were attached to the belt in order to support the barbell for the exercise.

IV. TESTING PROCEDURES

Pre-testing Period

On the first day of the study, the subjects were informed as to the nature of the experiment and their expected part in the procedures. Three class periods for each of the four participating classes were devoted to familiarizing the subjects with the techniques involved in the testing.

Harvard Step Test

During the pre-testing period the subjects practiced procedures in the administration of the Harvard Step Test. Several one-minute stepping trials were given. After each one-minute stepping exercise, the entire procedure for counting the pulse at the different intervals of time after exercise was practiced. All subjects were trained on the course of action to follow in the event that they were unable to perform the exercise for the entire five minutes. In this practice the investigator randomly assigned certain subjects to raise their arms and verbally indicate that they were unable to continue. Those assigned to count these subjects' pulses proceeded to record the stepping time and begin counting the pulse after one minute had elapsed.

Leg Strength

The subjects were acquainted with the procedures of the leg strength test and allowed to overcome initial inhibitions of technique by actually being tested several times prior to the formal initial tests were administered. The subjects assumed the testing position on the bench, and the correct angle between the thigh and lower leg was determined by the goniometer. After the angle was determined, the belt was placed in the correct position over the hips. These adjustments were recorded and used during the subsequent week of testing. This procedure allowed the belt to be quickly adjusted on each subject during the formal testing. However, the angle was again checked during testing in order to eliminate any possibility of error. The subjects were allowed to exert full strength during pre-test training to accustom themselves to the feel of maximum exertion in the testing position.

Muscular Endurance

The training for the test of muscular endurance of the legs consisted of having the subjects perform a limited version of the test with a small amount of weight on the barbell. In this way the subjects were able to acquire a degree of skill in keeping the back parallel to the floor and to maintain the necessary cadence while raising and lowering the weight with the legs. This time was also utilized to establish the correct adjustment in the testing apparatus for each

subject. These adjustment positions were recorded and greatly facilitated the actual testing.

Testing Period

Three days were necessary for the administration of the three tests. The Harvard Step Test was given on the first day. The second day of testing was devoted to the measurement of leg strength. The test of muscular endurance of the legs was given on the third day. Make-up tests were given on the third testing day for those who were absent for either of the previous tests. The same procedures were repeated at the end of the training program.

Procedures for Cardio-vascular Fitness Testing

The Harvard Step Test was utilized in this study to measure cardio-vascular fitness. This test consisted of having the subject step up and down on a step bench twenty inches high at a cadence of thirty times per minute for five minutes unless he stopped from exhaustion before then. As soon as the five minutes elapsed, the subject sat on the bench, and his pulse rate was counted from 1 to $1\frac{1}{2}$ minutes, 2 to $2\frac{1}{2}$ minutes, and 3 to $3\frac{1}{2}$ minutes after the cessation of the stepping exercise. In the event that a subject had to stop from exhaustion prior to the end of the five-minute exercise period, his time was noted and the pulse counts then taken at the specified intervals after exercise. The score was determined by dividing the duration of the exercise by the sum of pulses in recovery by the formula:

$$\text{Cardio-vascular Efficiency Score} = \frac{\text{Duration of the exercise in seconds X 100}}{\text{2 X Sum of the pulse counts in recovery}}$$

The Harvard Step Test is probably the most widely used test of cardio-vascular efficiency in physical education and was developed by Brouha[4] as a method of measuring physical fitness for muscular work in young men. This test was originally validated against the criterion of a work index based on the three factors of endurance running, maximum heart rate per minute, and blood lactate level. For a more complete description and history of the development of this test the reader is referred to the original article by Brouha.[5]

In the administration of this test, the subjects were assigned to groups of three. While one subject was being tested the other two assisted in the administration of the test by counting the subject's pulse rate after the cessation of exercise. This count was taken at both the radial and carotid arteries by the subjects who were assisting. In the event that the two totals did not agree, provision was made to use the average of the two counts as the valid measure. However, there was excellent agreement among the counters and this was not necessary.

Procedures for Testing Leg Strength

Leg strength was measured by means of the iso-scale. The subject

---

[4] Lucien Brouha, "The Step Test: A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, XIV (March, 1943), 31-36.

[5] Ibid.

was requested to step up onto the testing bench and assume a position that placed his back parallel to the floor. He then grasped one of the bars on the front of the bench at the level that would allow him to maintain balance. A webbing strap was placed over the subject's hips. He was instructed to bend his knees until the thigh and leg formed an angle of 100 degrees at the knee, at which point the strap was attached to the steel shaft behind his knees and divested of any slack. (See Figure 1.) The angle of the subject's knees was checked by means of the goniometer. The maximum indicator hand of the iso-scale was placed at zero. The subject was instructed to try to extend his legs as forcibly as possible with a strong steady pull, keeping his back parallel to the floor and his hands on the front of the bench. In cases where adjustment of the strap was not satisfactory, or the pulling action was jerky rather than smooth, the subject was re-tested. Sufficient trials were given to establish what was considered by the investigator to be a reliable score for each subject. All subjects were allowed to repeat the test later on during the period if they felt they would do better. The leg strength score was recorded by the tester to the nearest ten pounds.

Procedures for Testing Muscular Endurance of the Legs

This test involved measuring the isotonic muscular endurance of the legs by having the subject raise and lower a sub-maximal load. In

FIGURE 1

SUBJECT DEMONSTRATING THE LEG STRENGTH TEST
WITH THE ISO-SCALE

a survey of ergographic methods, Clarke[6] found that the amount of weight to be used for each subject could be effectively determined by taking a proportion of the strength of the muscles to be exercised. Through pre-test experimentation the writer found that one-half the subject's maximum leg strength at the 100 degree angle was sufficient to produce exhaustion in two minutes or less when this load was raised and lowered at a cadence of forty times per minute. As one-half the initial leg strength score might not necessarily be the final figure some means of equalizing the work done was needed.

In the initial test of muscular endurance of the legs, one-half of the initial leg strength at 100 degrees was used for the test whereas in the final test one-half of the final leg strength at 100 degrees was used. This resulted in two figures for each test, the number of repetitions and the weight used. In order to interpret this data, some means of equating these two scores was necessary to reach a single indication of work done. This was accomplished by multiplying the weight used by the number of repetitions. This resulted in a somewhat bulky figure which was divided by one hundred to facilitate treatment.

In the administration of this test, the subject was requested to step up onto the test bench, assume a position that placed his back parallel to the floor with his knees bent at an angle of 100 degrees as

---

[6]H. Harrison Clarke, Muscular Strength and Endurance in Man (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1966), p. 87.

determined by the goniometer. He then grasped one of the bars on the front of the bench in order to maintain a comfortable position. (See Figure 2.) A padded belt was then placed across the subject's hips with a chain on either side for attachment of a barbell which was loaded with the equivalent of one-half the subject's leg strength score. (See Figure 3.) The barbell, placed on two wooden chocks to compensate for ligament stretch, was attached to the chains and the chains were divested of any slack. The chocks were removed and the tape recorder was started. The subject then began to raise and lower the weight at a cadence of forty times per minute, as set by the tape recorder, for as long as possible. When the subject was unable to raise and lower the weight the full distance (see Figure 4, page 37) or if he failed to maintain the cadence, exhaustion was assumed to have been reached. At the conclusion of the test the subject's score was calculated by the formula $\frac{\text{Repetitions X Weight}}{100}$ and then recorded on the record sheet.

V. TRAINING PROGRAMS

Group I. The subjects in this group participated in an interval run of five minutes duration. The running program consisted of alternately running 120 yards at a slow (or intermediate) speed, followed by a run of eighty yards at a fast pace. This procedure was continued for five minutes each exercise session. The course was marked off in forty-yard intervals and markers were used for identifying or signaling the beginning and end of the distances for the different running speeds.

FIGURE 2

DEMONSTRATION OF THE USE OF THE GONIOMETER IN DETERMINING THE PROPER ANGLE OF THIGH AND LOWER LEG FOR THE LEG STRENGTH TEST

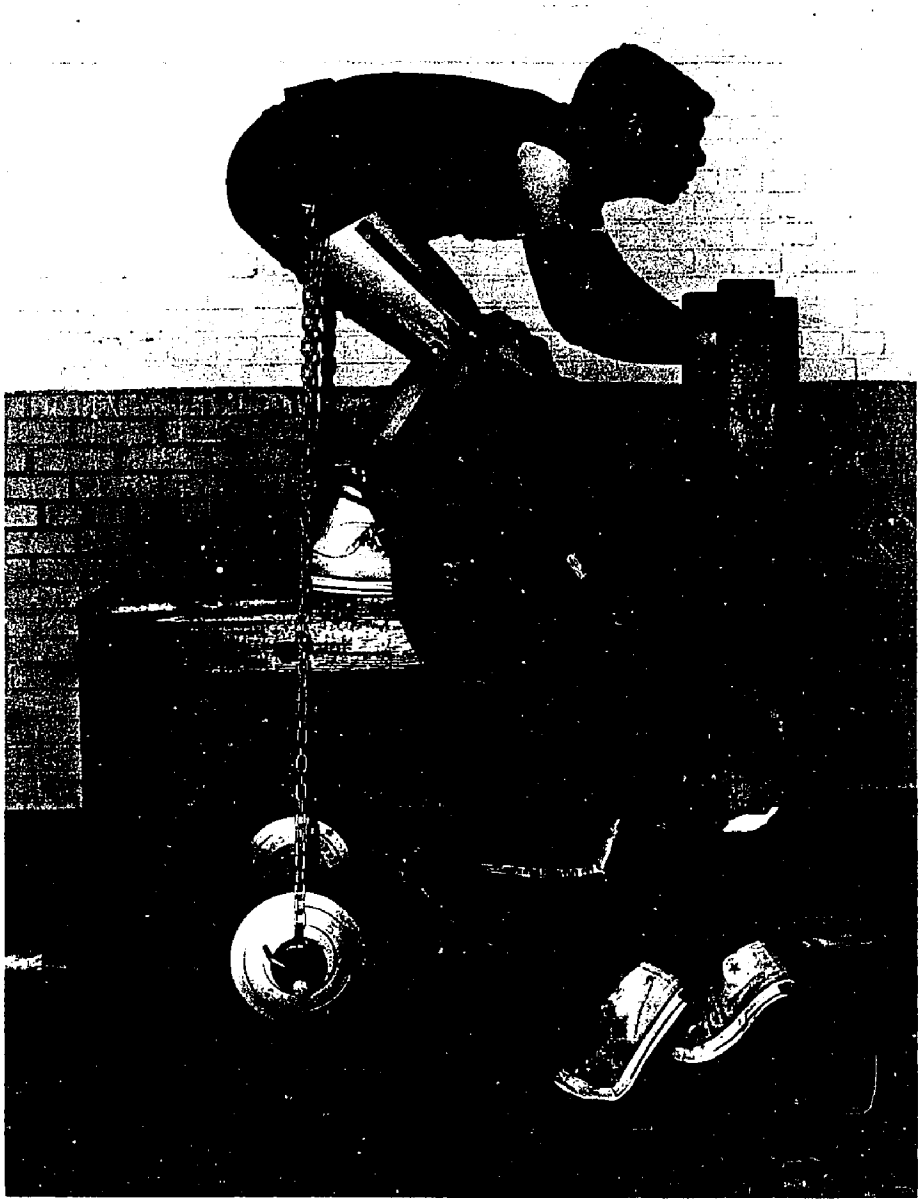


FIGURE 3

DEMONSTRATION OF THE STARTING POSITION AND THE EQUIPMENT UTILIZED IN THE TEST OF MUSCULAR ENDURANCE OF THE LEGS

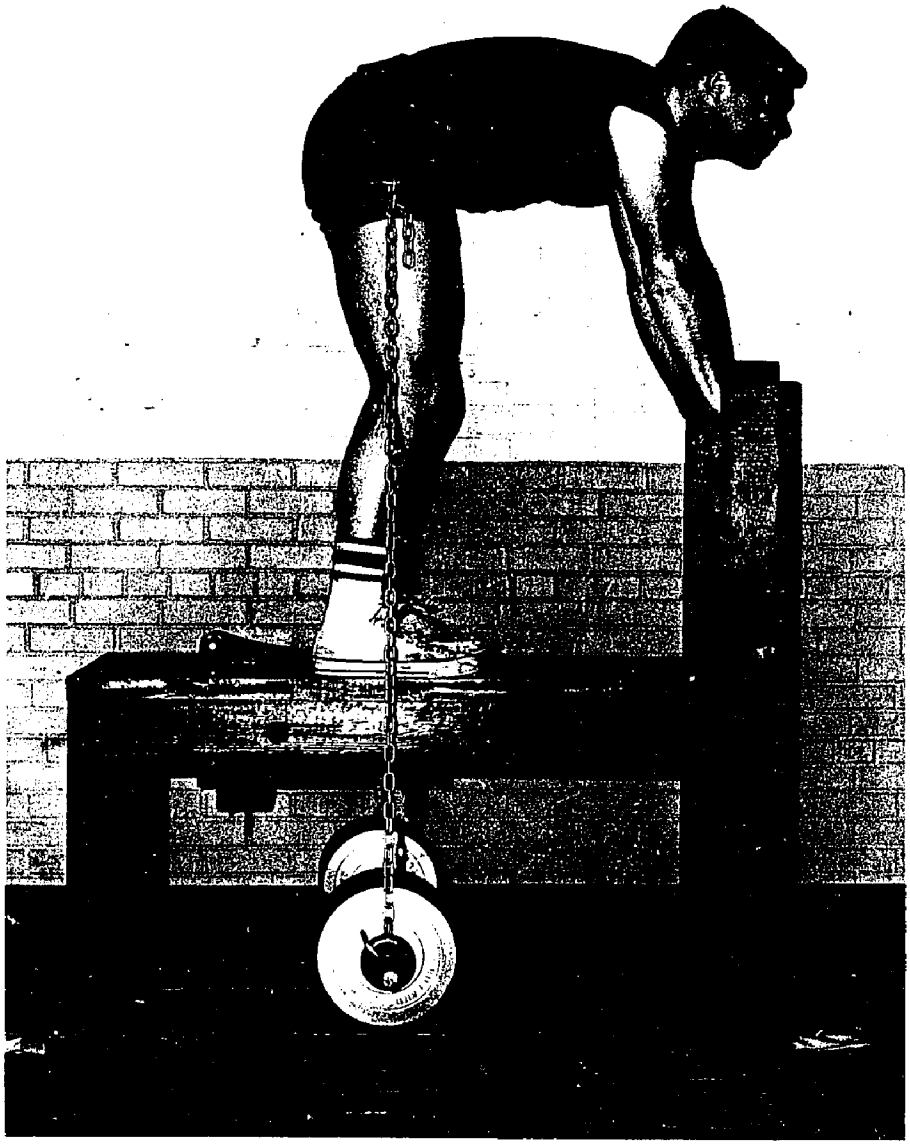


FIGURE 4

SUBJECT DEMONSTRATING THE EXTENDED POSITION IN THE TEST OF MUSCULAR ENDURANCE OF THE LEGS

An audible signal from the investigator indicated the termination of the time period for the interval run and the subjects halted and noted their respective zones which, with the number of circuits of the field provided a numerical indication of the distance covered. For example, if a runner had made three circuits or laps and the run was terminated in zone four, his score would be 3.4. This score was used for motivational purposes as well as a general indication of progress. In the event that a subject was unable to keep up with the group, he proceeded at his own pace and endeavored to increase his speed at the pre-determined points. In the event that a subject was unable to keep running, he was instructed to go into a walk-run situation for as long as possible.

Group II. The subjects in this group trained in a manner similar to the regular performance of the Harvard Step Test but with different cadences and utilizing a bench eighteen inches high. A mat two inches thick was placed adjacent to the bench in order to reduce the height of step required enabling the subjects to perform the faster pace of the exercise with a minimum of stumbling. The cadence was altered in that the first thirty seconds the subjects exercised at a pace of twenty-four steps per minute, which was followed by thirty seconds of stepping forty times per minute. The cadence then slowed to twenty-four times per minute for one minute; and the final thirty seconds of the test was performed at forty steps per minute. The total time for each training period was $2\frac{1}{2}$ minutes. The total time each subject was able to keep in step was recorded and used for motivational purposes.

Group III. Four functional isometric exercises were performed by this group in this study. The subjects performed four leg exercises for eight seconds at maximum effort, three days a week for a period of six weeks. Nylon belts were used in conjunction with a steel bar and testing benches to provide resistance in these exercises. Iso-scales were used on two of the exercises once a week and the scores recorded and used for motivational purposes. The exercises were performed as described in the following paragraphs.

Isometric leg extension. This exercise was done in the position at which the test of leg strength was accomplished and which represented the starting position for the test of muscular endurance of the legs. The subject stepped onto the bench and assumed a squatting position, placing the belt across his hips. The position for placement of the belt and bar had been determined previously and was facilitated by making holes in the bench, through which the bar was placed in order to make it possible to have different angles of pull. The subject then extended his knees to take the slack out of the belt and placed his hands on his knees keeping his back straight and parallel to the floor. At an audible signal the subject exerted maximum force with his legs extended for a period of eight seconds, at which time another audible signal was given to signal cessation of the exercise. This exercise is shown in Appendix B.

Isometric leg curl. The subjects were divided into pairs for the performance of this exercise. (See Appendix C.) One of the students

assumed a prone position with his knees partially extended, midway between flexion and extension at an approximate angle of ninety degrees. His partner firmly grasped his ankles and he then attempted to flex his knees for a period of eight seconds while his partner provided resistance.

Isometric toe raise. In this exercise the subject was seated in a chair placed on top of the step test bench. A nylon strap was placed over the subject's knees and secured to the bench so as to provide resistance when the subject raised his heels. The subject performed the exercise by raising his heels and forcing his knees against the belt for eight seconds at maximum effort. This exercise is shown in Appendix D.

Isometric inward leg push. The subject assumed a squatting position and placed his right forearm between his knees with the hand on the left knee and the elbow against the right knee. The subject then attempted to push his knees together with maximum force for a period of eight seconds. This exercise is shown in Appendix E.

Group IV. The subjects in this group served as a control and performed no exercise program other than routine class activities during the training period. These activities were performed in a forty-minute period, three times a week. The total number of class periods available for this unit was divided into four parts, and one activity was taught during each block of time. Conditioning exercises, drills and practice skills, intra-class competition comprised each of

the instructional units in touch football, soccer, basketball, and wrestling. A detailed course outline is presented in Appendix A.

VI. STATISTICAL ANALYSIS

The data were analyzed by two procedures. The first was a comparison within groups to determine whether or not significant improvement was made by each of the groups on each of the three variables of cardio-vascular fitness, leg strength, and muscular endurance of the legs. The significance of the difference between correlated means as described by Garrett[7] was utilized for this comparison.

The second procedure was a comparison to determine if the mean changes in cardio-vascular fitness, leg strength, and muscular endurance of the legs differed significantly among groups after treatment. In order to make this comparison, it was first necessary to establish whether to use analysis of variance or co-variance. The Pearson Product Moment method of correlation was employed using initial scores and gains. As a result of these computations, one for each of the three variables, analysis of variance was employed to ascertain if significant differences existed among groups.

---

[7]Henry E. Garrett, Statistics in Psychology and Education (New York: David McKay Co., 1952), p. 226.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

I. INTRODUCTION

The data obtained in this study consisted of initial and final scores for cardio-vascular fitness, leg strength, and muscular endurance of the legs. The first statistical analysis of the data in this study was to establish the significance of the gains made in each variable for each group. The formula for comparison of correlated means was used to determine the significance of the difference between initial and final scores in the development of cardio-vascular fitness, leg strength, and muscular endurance of the legs.

II. THE SIGNIFICANCE OF THE MEAN GAINS OF THE FOUR GROUPS IN CARDIO-VASCULAR FITNESS, LEG STRENGTH, AND MUSCULAR ENDURANCE OF THE LEGS

The significance of the mean gains in cardio-vascular fitness was determined by testing the null hypothesis by means of the t-ratio. In each comparison, the correlated group method was utilized because of the fact that the same subjects comprised both sets of scores.

Comparison of Initial and Final Cardio-Vascular Fitness Scores

From Table I it can be seen that the t-ratio resulting from the

comparison of difference between initial and final cardio-vascular fitness scores for Group I was 4.2. In order to be significant, a t-ratio of 2.04 was needed for the .05 level of confidence and a t of 2.76 was needed for the .01 level. Since the t of 4.2 was above the 2.76 ratio needed at the .01 level of probability, it may be stated that an interval run of five minutes in addition to the regular physical education activity resulted in significant improvements in cardio-vascular fitness.

Group II, which performed the stepping exercise, had a mean gain of 7.5 points in cardio-vascular efficiency scores from initial to final testing. The resulting t-ratio of 3.1 was above that of 2.76 needed for significance at the .01 level of confidence. This finding indicates that participation in the stepping exercise along with physical education activity as used in this study resulted in a significant improvement in cardio-vascular fitness.

Group III, which performed isometric exercises, had a mean gain of 14.1 points from initial to final testing with a resulting t-ratio of 7.4. This was clearly above the figure necessary for significance at the .01 level. It may be stated that the isometric program in conjunction with physical education activity resulted in significant gains in cardio-vascular fitness.

The mean gain from initial to final testing for Group IV, which served as the control group, was 9.4 which resulted in a t-ratio of 4.9. This gain was also significant at the .01 level of probability

TABLE I

COMPARISON OF THE DIFFERENCES BETWEEN THE INITIAL AND FINAL MEANS IN CARDIO-VASCULAR FITNESS SCORES OF FOUR GROUPS OF COLLEGE MEN

Group	N	Initial Mean	Final Mean	Mean of Gains	SE of Difference	t	P
Group I (Running)	30	73.1	82.3	9.2	2.18	4.2	.01
Group II (Stepping)	30	79.7	87.2	7.5	2.4	3.1	.01
Group III (Isometric)	30	75.6	89.7	14.1	1.9	7.4	.01
Group IV (Control)	30	71.8	81.2	9.4	2.2	4.9	.01

t needed at .05 level = 2.05; t needed at .01 level = 2.76

and indicated that the activities performed in the physical education class resulted in a significant increase in cardio-vascular fitness.

The results of Table I, page 44, indicate that all four groups made significant gains in cardio-vascular fitness at the .01 level of confidence.

Comparison of Initial and Final Leg Strength Scores

In Table II the results of the analysis indicate that the subjects in Group I, who participated in the interval run, had a mean gain in leg strength of 41.0 pounds. This resulted in a t-ratio of 4.9 which was above the 2.76 ratio needed for significance at the .01 level of probability. Thus, it may be stated that physical education activity and supplementary interval running resulted in an increase in leg strength.

The group that performed the stepping exercise (Group II) had a mean gain in leg strength of 32.7 pounds from initial to final testing. The resulting t-ratio of 3.4 was larger than that needed for the .01 level of confidence and indicated that the stepping exercise in addition to physical education activity resulted in increased leg strength in the subjects.

Group III, the isometric exercise group, had a mean gain of 65.7 pounds in leg strength with a resulting t-ratio of 5.2. This was also significant at the .01 level. Thus, isometric exercises and physical education activity resulted in a significant gain in leg strength.

TABLE II

COMPARISON OF THE DIFFERENCES BETWEEN THE INITIAL AND FINAL MEANS IN LEG STRENGTH SCORES FOR FOUR GROUPS OF COLLEGE MEN

Group	N	Initial Mean in Pounds	Final Mean in Pounds	Mean of Gains	SE of Difference	t	P
Group I (Running)	30	295.0	336.0	41.0	8.35	4.9	.01
Group II (Stepping)	30	292.6	325.3	32.7	9.5	3.4	.01
Group III (Isometric)	30	251.3	317.0	65.7	12.6	5.2	.01
Group IV (Control)	30	261.0	292.3	31.3	10.3	3.2	.01

t needed at .05 level = 2.05; t needed at .01 level = 2.76

It was also found that Group IV, the control group, had a mean gain of leg strength of 31.3. This resulted in a t-ratio of 3.2 and indicated significant gains in leg strength at the .01 level of confidence were brought about by physical education activity alone.

The results from Table II, page 46, indicate that all four groups did make significant gains in leg strength at the .01 level of probability.

Comparison of Initial and Final Scores of Muscular Endurance of the Legs

In Table III the mean gain for Group I, the interval running group, is shown to be 17.9. This resulted in a t-ratio of 2.5. This exceeded the 2.04 ratio needed for significance at the .05 level but did not reach that of 2.76 required for the .01 level of probability.

Group II, the step training group, showed a mean gain in muscular endurance of the legs of 21.4. This resulted in a t-ratio of 3.4 which was in excess of the 2.76 required for significance at the .01 level of confidence. These results indicate that the training program for this group resulted in a significant increase in muscular endurance of the legs.

Group III, the isometric exercise group, had a mean gain in muscular endurance of the legs of 25.6 which resulted in a t-ratio of 4.4. This result was significant at the .01 level of confidence and indicated that muscular endurance of the legs was improved by the training program followed by this group.

TABLE III

COMPARISON OF THE DIFFERENCE BETWEEN THE INITIAL AND FINAL MEANS IN MUSCULAR ENDURANCE OF THE LEGS SCORES FOR FOUR GROUPS OF COLLEGE MEN

Group	N	Initial Mean	Final Mean	Mean of Gains	SE of Difference	t	P
Group I (Running)	30	96.5	114.4	17.9	7.2	2.5	.05
Group II (Stepping)	30	89.4	110.8	21.4	6.3	3.41	.01
Group III (Isometric)	30	84.3	109.9	25.6	5.8	4.4	.01
Group IV (Control)	30	78.3	93.6	15.3	5.4	2.84	.01

t needed at .05 level = 2.05; t needed at .01 level = 2.76

Group IV, the control group, had a mean gain of 15.3 in muscular endurance of the legs. The resulting t-ratio of 2.8 was in excess of the 2.76 ratio required for the .01 level of probability and indicated that the physical education activities practiced in this study resulted in an increase in muscular endurance.

The results of Table III, page 48, show that all four of the training groups made significant gains in muscular endurance of the legs. The only dissimilarity evidenced was that the gains for Group I were significant at the .05 level whereas the other groups had significant gains at the .01 level of confidence.

III. ANALYSIS OF VARIANCE

For the variables of cardio-vascular fitness, leg strength, and muscular endurance of the legs, analysis of variance was utilized to determine if there were significant differences among the groups as a result of the training programs. In determining whether to use analysis of variance or co-variance, the original test scores, for all groups, taken together, in each variable, were correlated against the gains made as a result of training. If there was a relatively high coefficient of correlation this would indicate that the final results were considerably affected by the initial scores. As an arbitrary criterion, a correlation of $\pm$ .50 or above was established. If a correlation of .50 was obtained it would mean that 25 per cent of the variability of the final scores was due to the initial scores and that

this should be compensated for by employing co-variance to statistically equate the groups.

The r's obtained between the initial test scores and the gains for cardio-vascular fitness, leg strength, and muscular endurance of the legs were all well below $\pm$ .50; therefore, analysis of variance was employed.

Analysis of Variance for Cardio-Vascular Fitness Test Scores

Analysis of the cardio-vascular fitness test scores data revealed an F-ratio of .32. For 3 and 116 degrees of freedom shown in Table IV, F-ratios of 2.69 and 4.80 were needed for significance at the .05 and .01 levels of confidence, respectively. The F-ratio obtained was clearly below the value needed to meet the test of significance at the .05 level, which meant that there were no differences among the four groups in cardiovascular fitness improvement.

Analysis of Variance for Leg Strength Test Scores

The F-ratio found from an analysis of variance of the leg strength scores also indicated no significant differences existed among groups. The obtained F-ratio of 2.12 was clearly not significant at the .05 level of confidence.

Analysis of Variance for Muscular Endurance of the Legs Test Scores

In Table IV the results of the analysis of variance showed an F-ratio of .57 for the comparison of the four groups in muscular

TABLE IV

ANALYSIS OF VARIANCE FOR COMPARISONS OF MEAN GAINS AMONG THE FOUR GROUPS OF COLLEGE MEN IN CARDIO-VASCULAR FITNESS, LEG STRENGTH, AND MUSCULAR ENDURANCE OF THE LEGS

Type of Test	Source of Variation	Corrected SS	df	Mean Squares	F	P
Cardio-vascular Fitness	Between	110	3	336.6	.32	NS
	Within	13,601	116	117.2		
	Total	13,711	119			
Leg Strength	Between	22,423	3	7474.2	2.12	NS
	Within	409,577	116	3530.8		
	Total	432,000	119			
Muscular Endurance of the Legs	Between	2,494	3	831.2	.57	NS
	Within	167,490	116	1443.8		
	Total	169,984	119			

F needed at .05 level, 2.69; at .01 level, 4.80

endurance scores. This F-ratio was not significant and indicated that no difference in muscular endurance scores existed among the four groups.

CHAPTER V

SUMMARY, FINDINGS, AND CONCLUSIONS

I. SUMMARY

It was the purpose of this study to determine the effects of three exercise routines of short duration, given in conjunction with a regular physical education program, on the development of cardiovascular fitness, leg strength, and relative muscular endurance of the legs of a selected group of college males.

One hundred twenty male students at Pembroke State College, Pembroke, North Carolina served as subjects for this study. The subjects were divided into four groups: Group I performed a five-minute interval run in addition to the regular required program of physical education; Group II performed a specially designed stepping exercise of two and one-half minutes duration along with the physical education activity; Group III performed a program of four isometric exercises for a period of eight seconds for each exercise in addition to the physical education program; and Group IV, the control group, participated only in the regular required program of physical education. All subjects took part in the same physical education activities, consisting of soccer, touch football, basketball, and wrestling. The first week of the experiment was devoted to orientation and pre-test training to familiarize the subjects with the tests and their

administration. All groups were tested the following week in order to establish the initial scores on the variables involved in the study. The subjects then trained three days a week for six weeks.

At the end of the six-week training period, all subjects were re-tested in an effort to determine whether or not significant changes in cardio-vascular fitness, leg strength, and muscular endurance of the legs occurred during the study.

The *t*-test was used to determine the significance of the gains made between the initial and final tests of cardio-vascular fitness, leg strength, and muscular endurance of the legs. Analysis of variance was utilized to determine if there were significant differences among the four groups in the gains made in each of the variables.

II. FINDINGS

The findings of this study were as follows:

1. The gains made in cardio-vascular fitness by all four groups were significant at the .01 level of probability. No significant differences were found among the four groups in cardio-vascular fitness gains.
2. All four groups showed significant improvement in leg strength after six weeks of training. The gains were significant at the .01 level of probability. When the groups were compared, no significant differences in leg strength gains were found.

3. The gains made in muscular endurance scores were significant at the .01 level of probability for all four groups. No significant differences existed among the four groups in the amount of improvement made in muscular endurance scores.

III. DISCUSSION OF FINDINGS

Ordinarily, it might seem strange or even suspicious that the control group would perform as well as the experimental groups in all of the variables. However, the control group in this study was not merely a "test-retest" group with no intervening activity. It must be reiterated that all of the subjects in all four of the groups were participating in physical education classes. Therefore, the experimental groups, in reality, had only a few minutes of concentrated, specific exercises that the control group did not.

Of primary importance was the nature of the physical education activities in which all of the subjects participated. The activities (touch football, soccer, basketball, and wrestling) are all strenuous sports involving a great deal of physical stamina. Of even greater pertinence to the findings of this study was the manner in which these activities were conducted. Much of the class time was spent in conditioning work including running and exercises. There were very few occasions in which the subjects were inactive or stationary. The drills employed in practicing skills in these sports, particularly in soccer and wrestling, demanded vigorous movement; furthermore, actual

competition in all of the activities involved a great deal of running and physical stress. The investigator emphasized maximum effort and continually exhorted all of the subjects to exert as hard as they could. Consequently, the control group as well as the experimental groups were subjected to a considerable amount of exercise for thirty-five minutes a day, three times per week.

It should be evident from the preceding discussion that gains in selected measures of physical condition by the control group were not totally unexpected. This study was primarily concerned with determining whether the addition of specific exercise routines would bring about significant improvement in conditioning over and above the regular training activities. Based on the review of literature, it was hypothesized that certain exercise routines would have some advantage in certain measures of fitness. For example, due to the frequently observed relationship of specificity of practice to performance, it was thought that superiority might be evidenced in leg strength performance by the isometric exercise group, and in the Harvard Step Test by the bench stepping group. However, this was not the case. Evidently, the physical education activities were able to produce sufficient stress that in turn realized significant improvement in the physical measures that were measured in this study.

IV. CONCLUSION

Within the limits of this study, it was concluded that significant

gains in cardio-vascular fitness, strength and endurance can be brought about by placing the individual under sufficient stress. The nature of the conditioning program is not the important consideration as long as it is sufficiently strenuous.

V. RECOMMENDATION

Based on the findings of this study, it is recommended that a similar investigation be conducted using less strenuous physical education activities such as golf, archery, badminton, and others to ascertain whether or not these supplementary exercise programs would be of more effectiveness.

SELECTED BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

A. BOOKS

Bovard, John, Frederick W. Cozens, and E. Patricia Hagman. Tests and Measurement. Philadelphia: W. B. Saunders Company, 1949. 410 pp.

Carlsten, Arne, and Gunnar Grimby (editors). The Circulatory Response to Muscular Exercise in Man. Springfield: Charles C. Thomas Company, 1966. 129 pp.

Clarke, H. Harrison. Muscular Strength and Endurance in Man. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966. 211 pp.

deVries, Herbert A. Physiology of Exercise. Dubuque, Iowa: William C. Brown and Company, 1966. 442 pp.

Garrett, Henry E., and R. S. Woodworth. Statistics in Psychology and Education. New York: David McKay Company, 1958. 478 pp.

Hoffman, Robert, Martin Broussard, Alvin Roy, and Francis A. Drury. Functional Isometric Contraction for Football. New York: Bob Hoffman Foundation, 1962. 51 pp.

Johnson, Warren R. (editor). Science and Medicine of Exercise and Sports. New York: Harper and Brothers, 1960. 740 pp.

Jokl, Ernst (editor). Heart and Sport. Springfield: Charles C. Thomas Company, 1964. 117 pp.

Meyers, Carlton R., and T. Erwin Blesh. Measurement in Physical Education. New York: Ronald Press, 1962. 332 pp.

Morehouse, Lawrence E., and Philip J. Rasch. Sports Medicine for Trainers. Philadelphia: W. B. Saunders Company, 1963. 235 pp.

Scott, Phebe M., and Virginia R. Crofts. Track and Field for Girls and Women. New York: Appleton-Century-Crofts, 1964. 220 pp.

Steinhaus, Arthur H. Toward an Understanding of Health and Physical Education. Dubuque, Iowa: William C. Brown Company, 1963. 376 pp.

B. PERIODICALS AND PUBLICATIONS

Alost, Robert A. "Effects of Initial Cardio-Vascular Condition Type of Training Program, and Frequency of Practice upon Cardio-Vascular Development," 67th Proceedings of the National Physical Education Association for Men, (1964), 29 pp.

Andersen, K. Lange. "Measurement of Work Capacity," The Journal of Sports Medicine, IV (December, 1964), 236-240.

Brouha, Lucien. "The Step Test, A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, XIV (March, 1943), 31-36.

_____, Norman W. Fradd, and Beatrice M. Savage. "Studies in Physical Efficiency of College Students," Research Quarterly, XV (October, 1944), 211-224.

Christensen, Erik H., Rune Hedman and Bengt Saltin. "Intermittent and Continuous Running," Acta Physiology Scandanavia, L (1960), 269-286.

Cogswell, Robert C., Charles R. Henderson, and George H. Berryman. "Some Observations of the Effects of Training on Pulse Rate, Blood Pressure and Endurance in Humans, Using the Step Test (Harvard), Treadmill, and Electrodynamic Brake Bicycle Ergometer," The American Journal of Physiology, CXLVI (1946), 422-430.

Dennison, J. D., M. L. Howell, and W. R. Morford. "Effect of Isometric and Isotonic Exercise Programs upon Muscular Endurance," Research Quarterly, XXXII (1961), 348-352.

Freeman, M. E., G. L. Snider, P. Brostoff, S. Kimelblat, and L. N. Katz. "Effects of Training on Response of Cardiac Output to Muscular Exercise in Athletes," Journal of Applied Physiology, VIII (July, 1955), 37-47.

Frick, M. Heikki, Arne Kontinen, and H. S. Samuli Sarojas. "Effect of Physical Training on Circulation at Rest and During Exercise," The American Journal of Cardiology, XII (August, 1963), 142-147.

Hettinger, Thomas and E. A. Muller. "Muskelleistrung and Muskel-training," Arbeitsphysiologie, XV (1953), 111-126. Quoted in International Research in Sport and Physical Education. Edited by E. Jokl and E. Simon. Springfield: Charles C. Thomas Company, 1964. 730 pp.

Howell, Maxwell L., Ray Kimoto, and W. R. Morford. "Effects of Isometric and Isotonic Exercise Programs upon Muscular Endurance," Research Quarterly, XXXIII (December, 1962), 536-540.

Hunsicker, Paul, and George Greey. "Studies in Human Strength," Research Quarterly, XXVIII (May, 1957), 109-122.

Karpovich, Peter V. "Fatigue and Endurance," Research Quarterly, Supplement XII (May, 1941), 416-422.

Knehr, C. A., D. B. Dill, and William Neufeld. "Training and Its Effects on Man at Rest and at Work," American Journal of Physiology, XXXVI (March, 1942), 148-156.

Michael, Ernest D., and Arthur Gallon. "Periodic Changes in the Circulation During Athletic Training as Reflected by a Step Test," Research Quarterly, XXX (October, 1959), 303-311.

Miller, Waldow A., and Edwin R. Elbel. "The Effect upon Pulse-Rate of Various Cadences in the Step-up Test," Research Quarterly, XVII (December, 1946), 263-269.

Muller, E. A., and W. Rohmert. "Die Geschwindigkeit der Muskelkraft Zunahme bei Isometrischen Training," Int. Z. Agnew Physiol. einschl. Arbeitsphysiologie, XIX (1963), 403-419. Quoted in deVries, Herbert A., Physiology of Exercise. Dubuque: Wm. C. Brown, 1966. 422 pp.

Mullison, Don W. Isometric Exercise. Laramie, Wyoming: Idead, 1964. 63 pp.

Rasch, Philip J. "Endurance Training for Athletes," Journal of the Association for Physical and Mental Rehabilitation, XIII (Nov.-Dec., 1959), 182-185, +197.

Schneider, Edward C. "A Cardiovascular Rating as a Measure of Physical Fatigue and Efficiency," Journal of the American Medical Association, LXXV (1920), 1507-1510.

Smodlaka, Vojin. "Internal Training in Heart Disease," The Journal of Sports Medicine and Physical Fitness, XXX (June-September, 1963), 93-100.

Thompson, Clem W. "Some Physiologic Effects of Isometric and Isotonic Work in Man," Research Quarterly, XXV (December, 1954), 476-482.

Vanderfog, Ellen R., Charles J. Imig, and H. M. Hines. "Effect of Muscle Strength and Endurance Development on Blood Flow," Journal of Applied Physiology, XVI (September, 1961), 873-877.

Wallace, Joseph. "The Development of Muscular Strength and Muscular Endurance Through Isotonic and Isometric Exercise," New Zealand Journal of Physical Education, XIV (April, 1958), 3-9. Cited in International Research in Sport and Physical Education. Edited by E. Jokl and E. Simon. Springfield: Charles C. Thomas Company, 1964. 730 pp.

Wallers, C. E., C. L. Stewart, and J. F. LeClaire. "Effect of Short Bouts of Isometric and Isotonic Contractions on Muscular Strength and Endurance," American Journal of Physical Medicine, XXXIX (August, 1960), 131-141.

Wang, Yang, John T. Shepherd, Robert J. Marshall, Loring Rawell, and Henry L. Taylor. "Cardiac Response to Exercise in Unconditioned Young Men and in Athletes," Circulation, XXIV (1961), 1064.

White, H. L., and R. M. Moore. "Circulatory Responses to Static and Dynamic Exercise," American Journal of Physiology, LXXIII (1925), 636.

C. UNPUBLISHED MATERIALS

Coach's Sporting Goods Corporation. Marion, Indiana. Iso-Scale.

Columbia Manufacturing Company, New York, New York. Tape recorder.

Kirby, Ronald F. "The Effects of Various Exercise Programs Involving Different Amounts of Exercise on the Development of Certain Components of Physical Fitness." Unpublished Doctoral dissertation, Louisiana State University, 1966.

Marley, William P. "The Comparative Effectiveness of Isometric Exercise and Isotonic Exercise in the Development of Muscular Strength, Endurance, and Girth." Unpublished Master's thesis, University of Maryland, 1962.

Milton, George C. "The Effects of Three Programs of Long Distance Running and an Isometric Exercise Program on the Development of Cardio-Vascular Efficiency." Unpublished Doctoral dissertation, Louisiana State University, 1966.

Mole, Paul Angelo. "The Influence of Interval Running on the Aerobic Metabolism and Endurance Performance of Four Young Men." Unpublished Master's thesis, University of Illinois, Urbana, 1960.

Scannell, Robert James. "Selected Factors Concerned with the Maintenance of Endurance." Microcarded Master's thesis, The Pennsylvania State University, 1959.

Taylor, Bruce M. "The Effects of Certain Fitness Programs upon the Cardio-Vascular and Muscular Status of Businessmen." Unpublished Master's thesis, University of British Columbia, 1961.

Zeigler, Robert G. "The Frequency of Maximum Effort Most Favorable for the Development of Endurance in College Students." Unpublished Master's thesis, Pennsylvania State University, 1960.

APPENDIXES

APPENDIX A

COURSE OUTLINE OF BASIC PHYSICAL EDUCATION ACTIVITY CLASS

FALL SEMESTER, 1966-67

The objective of the basic physical education class as taught at Pembroke State College was to provide all students with the opportunity to learn and participate in indoor and outdoor sports and to participate in and enjoy leisure time recreation consistent with their abilities and interests.

The costume worn for the classes was the regulation uniform prescribed by the department, consisting of black shorts, gold and black reversible T-shirt, white socks, supporter, and tennis shoes. Sweat clothes were permitted on an optional basis.

The classes met from five minutes after the scheduled hour until fifteen minutes before the next hour, resulting in a total of forty minutes in class. The first five minutes of the class time for the experimental groups was devoted to the training programs described in the body of this paper. The first five minutes of the control group was devoted to roll call and for the purpose of informing the class of the schedule of the day's activities. Therefore, each of the four groups had a schedule that resulted in thirty-five minutes, three days a week, of actual participation in physical education activities. One and one-half weeks were devoted to each of the four activities (touch football, soccer, basketball, and wrestling.) Considerable emphasis was given to drills and conditioning exercises.

The latter part of each unit was devoted to competition within the class, in the particular sport. A breakdown of the specific activities was as follows:

Touch Football

Phases of Instruction

1. Fundamental positions
   a. Lineman's stance - regular and modified
   b. Back stance - regular and upright

2. Skills in playing the game
   a. Blocking
   b. Skills in providing protection for the passer
   c. Pass reception
   d. Pass defense
   e. Skills in using interference properly
   f. Running attack
   g. Pass patterns
   h. Skills in kicking
   i. Skills in covering kicks

3. The rules of touch football
   a. Touch defined
   b. Legal and illegal strategy
   c. Offside rule
   d. First down rule
   e. Unnecessary roughness

4. Intra-class competition

Soccer

Phases of Instruction

1. Skills in trapping the ball
   a. Stationary high trap
   b. Letting the ball down
   c. High drag trap
   d. Low drag trap
   e. Low withdrawal trap
   f. Knee trap
   g. Chest trap

2. Skills in kicking the ball
   a. Inside of foot kick
   b. Instep kick
   c. Instep volley
   d. Overhead kick
   e. Shooting
   f. Passing

3. Skills in heading the ball
   a. Heading the ball forward
   b. Heading the ball backward
   c. Sliding the ball
   d. Shooting header
   e. Heading the ball to feet

4. Positional skills
   a. Forward play
   b. Half-back play
   c. Full-back play
   d. Goal keeping

5. Strategy of the game
   a. Offensive theory
   b. Defensive theory

6. Knowledge of the rules

7. Intra-class competition

Basketball

Phases of Instruction

1. Skills in passing the ball
   a. Chest pass
   b. Bounce pass
   c. Hook pass
   d. One hand pass

2. Dribbling and shooting
   a. Dribbling, right and left hand
   b. Dribble in and lay-up shots from right and left sides
   c. Hook shot starting with back to basket
   d. One hand shots
   e. Two hand shooting
   f. Foul shooting

3. Drills for developing skill
   a. Lay-up drill
   b. Two on one
   c. Figure eight

4. Intra-class competition

Wrestling

Phases of Instruction

1. Fundamental positions
   a. Stance-regular and Oklahoma
   b. Referee's position - up and down

2. Takedowns
   a. Double leg
   b. Arm drag
   c. Head - drag
   d. Heel pickup
   e. Counters

3. Reverses
   a. Switch and counter-switch
   b. Side roll
   c. Sit-out

4. Escapes
   a. Stand-up
   b. Sit-out

5. Takedowns from behind
   a. Cross-over
   b. Back Heel

6. Takedowns face to face
   a. Slapdown
   b. Arm drag

7. Rides and breakdowns
   a. Arm lever
   b. Jerk over
   c. Cross face and ankle

8. Pinning combinations
   a. Tulsa special
   b. Half-Nelson combinations

9. The rules or wrestling
    a. Legal and illegal holds
    b. Weight classifications
    c. Length of matches
    d. Individual and team point scoring
    e. Falls and near falls
    f. Injuries and defaults

10. Intra-class competition

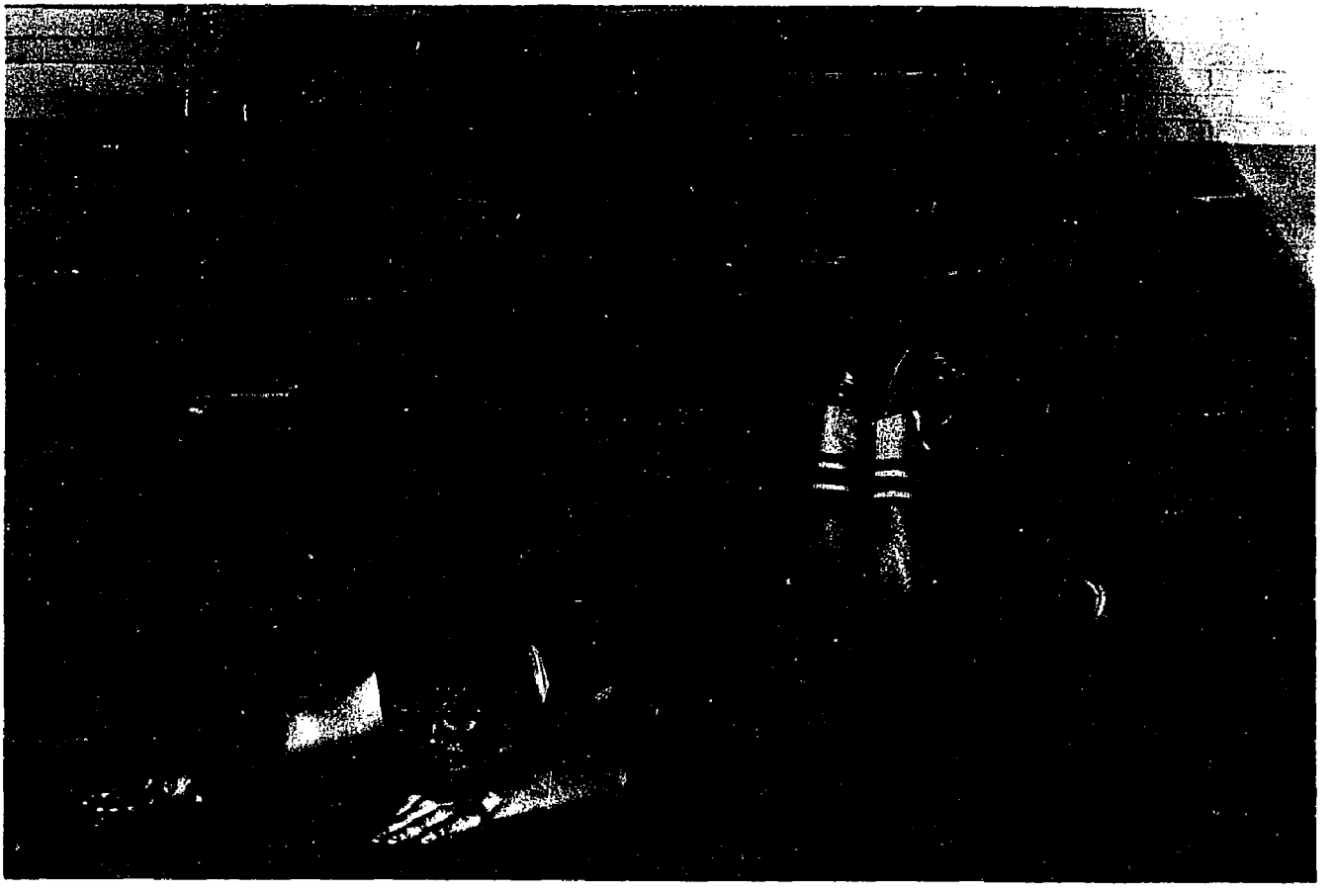
APPENDIX B

ILLUSTRATION OF LEG EXTENSION ISOMETRIC EXERCISE

This picture shows a side view of the leg extension exercise for the isometric training group.

APPENDIX C

ILLUSTRATION OF THE LEG CURL ISOMETRIC EXERCISE



This picture shows a side view of the leg curl exercise for the isometric training group.

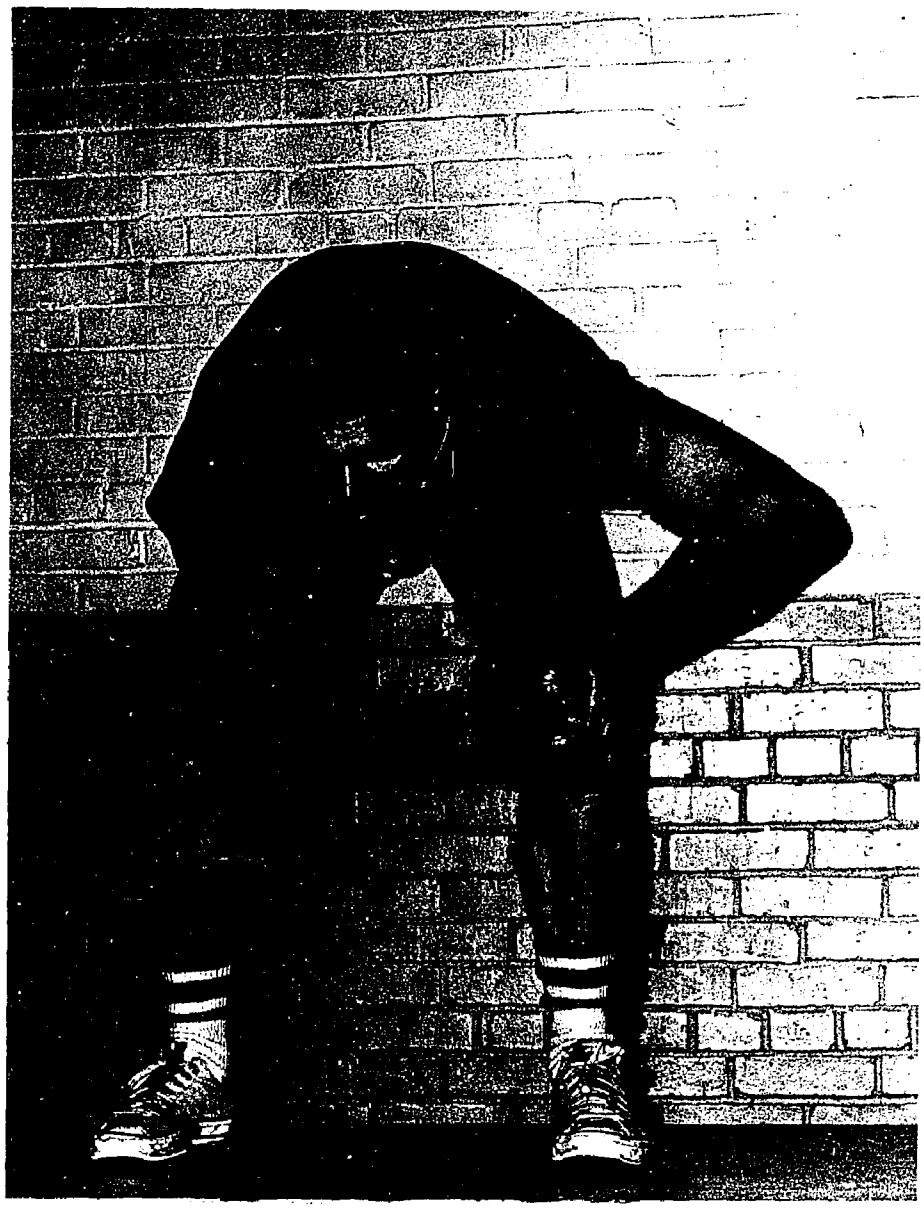
APPENDIX D

ILLUSTRATION OF THE TOE RAISE ISOMETRIC EXERCISE

This picture shows a side view of the toe raise exercise for the isometric training group.

APPENDIX E

ILLUSTRATION OF THE INWARD LEG PUSH ISOMETRIC EXERCISE



This picture shows a front view of the inward leg push exercise for the isometric training group.

APPENDIX F

INITIAL AND FINAL CARDIO-VASCULAR FITNESS SCORES AS MEASURED BY THE HARVARD STEP TEST FOR GROUP I

Subject	Initial Scores	Final Scores
1	74	95
2	76	81
3	66	90
4	76	86
5	74	79
6	79	87
7	75	55
8	41	62
9	77	63
10	75	104
11	76	87
12	49	50
13	74	98
14	81	59
15	81	110
16	79	90
17	81	93
18	88	90
19	75	77
20	79	79
21	60	79
22	61	72
23	79	90
24	74	86
25	74	90
26	37	53
27	81	87
28	87	106
29	81	87
30	84	84
Total	2194	2469
Mean	73.1	82.3

APPENDIX G

INITIAL AND FINAL CARDIO-VASCULAR FITNESS SCORES AS MEASURED BY THE HARVARD STEP TEST FOR GROUP II

Subject	Initial Scores	Final Scores
1	87	86
2	84	100
3	67	74
4	87	93
5	83	92
6	81	83
7	79	94
8	84	92
9	78	84
10	86	88
11	34	41
12	94	87
13	75	88
14	68	83
15	48	77
16	95	85
17	81	102
18	90	85
19	67	83
20	95	102
21	86	88
22	78	88
23	78	87
24	75	86
25	87	92
26	87	102
27	87	93
28	79	83
29	87	86
30	85	92
Total	2391	2516
Mean	79.7	87.2

APPENDIX H

INITIAL AND FINAL CARDIO-VASCULAR FITNESS SCORES AS MEASURED BY THE HARVARD STEP TEST FOR GROUP III

Subject	Initial Scores	Final Scores
1	51	68
2	78	78
3	72	115
4	87	84
5	87	111
6	75	83
7	78	84
8	75	88
9	81	84
10	75	93
11	96	100
12	91	93
13	78	84
14	81	86
15	81	103
16	88	94
17	95	97
18	94	93
19	75	86
20	81	92
21	81	86
22	94	70
23	81	100
24	87	93
25	78	72
26	74	88
27	75	100
28	88	103
29	75	79
30	78	84
Total	2268	2691
Mean	75.6	89.7

APPENDIX I

INITIAL AND FINAL CARDIO-VASCULAR FITNESS SCORES AS MEASURED BY THE HARVARD STEP TEST FOR GROUP IV

Subject	Initial Scores	Final Scores
1	72	75
2	72	77
3	75	84
4	87	100
5	69	67
6	65	88
7	84	93
8	76	90
9	72	73
10	75	81
11	80	88
12	86	77
13	55	72
14	65	81
15	76	80
16	36	72
17	81	95
18	93	85
19	87	84
20	50	72
21	76	87
22	69	84
23	84	76
24	74	93
25	71	76
26	62	76
27	72	75
28	72	82
29	46	75
30	71	79
Total	2154	2463
Mean	71.8	81.2

APPENDIX J

INITIAL AND FINAL LEG STRENGTH SCORES AS MEASURED BY THE ISO-SCALE FOR GROUP I

Subjects	Initial Scores	Final Scores
1	400	390
2	400	450
3	270	300
4	250	210
5	410	400
6	240	230
7	230	270
8	280	330
9	210	210
10	330	420
11	230	290
12	260	310
13	280	380
14	290	240
15	320	310
16	210	360
17	210	280
18	330	340
19	260	350
20	360	320
21	270	430
22	200	220
23	450	600
24	320	250
25	240	230
26	240	250
27	330	380
28	450	550
29	350	390
30	250	390
Total	8850	10080
Mean	295	336

Scores are measured in pounds.

APPENDIX K

INITIAL AND FINAL LEG STRENGTH SCORES AS MEASURED BY THE ISO-SCALE FOR GROUP II

Subjects	Initial Scores	Final Scores
1	280	330
2	360	380
3	280	290
4	210	240
5	220	190
6	210	220
7	310	400
8	220	250
9	210	230
10	250	260
11	550	450
12	240	280
13	220	240
14	320	350
15	350	270
16	240	250
17	280	380
18	410	450
19	330	380
20	210	360
21	320	300
22	400	440
23	230	250
24	310	400
25	300	320
26	310	380
27	210	310
28	310	390
29	390	340
30	300	430
Total	8778	9759
Mean	292.6	325.3

Scores are measured in pounds.

APPENDIX L

INITIAL AND FINAL LEG STRENGTH SCORES AS MEASURED BY THE ISO-SCALE FOR GROUP III

Subjects	Initial Scores	Final Scores
1	350	440
2	210	330
3	130	290
4	170	160
5	410	430
6	260	350
7	240	370
8	250	350
9	250	320
10	310	290
11	310	390
12	230	310
13	140	230
14	220	280
15	220	250
16	390	420
17	350	450
18	240	200
19	260	300
20	140	290
21	170	260
22	320	380
23	160	280
24	400	430
25	230	330
26	210	250
27	230	290
28	360	300
29	220	300
30	170	240
Total	7545	9510
Mean	251.5	317.0

Scores are measured in pounds.

APPENDIX M

INITIAL AND FINAL LEG STRENGTH SCORES AS MEASURED BY THE ISO-SCALE FOR GROUP IV

Subjects	Initial Scores	Final Scores
1	140	230
2	300	350
3	310	330
4	230	300
5	240	220
6	260	300
7	390	340
8	250	170
9	230	280
10	310	370
11	180	230
12	260	290
13	170	160
14	230	220
15	260	300
16	260	180
17	350	330
18	190	350
19	320	340
20	250	350
21	300	420
22	240	220
23	270	290
24	300	280
25	240	350
26	310	360
27	310	430
28	170	230
29	230	190
30	330	360
Total	7830	8769
Mean	261.0	292.3

Scores are measured in pounds.

APPENDIX N

INITIAL AND FINAL MUSCULAR ENDURANCE OF THE LEGS SCORES AS MEASURED IN THIS STUDY FOR GROUP I

Subjects	Initial Scores	Final Scores
1	42	111
2	158	185
3	130	135
4	75	47
5	84	156
6	109	139
7	62	83
8	42	74
9	33	105
10	135	143
11	59	197
12	86	133
13	66	80
14	52	93
15	96	105
16	147	162
17	63	104
18	86	72
19	66	70
20	83	42
21	74	107
22	84	105
23	112	180
24	122	88
25	75	65
26	82	43
27	99	106
28	280	250
29	105	117
30	188	136
Total	2895	3432
Mean	96.5	114.4

Scores were determined by the formula: $\frac{\text{repetitions X weight}}{100}$

APPENDIX O

INITIAL AND FINAL MUSCULAR ENDURANCE OF THE LEGS SCORES AS MEASURED IN THIS STUDY FOR GROUP II

Subjects	Initial Scores	Final Scores
1	71	167
2	131	184
3	134	160
4	92	126
5	111	104
6	65	83
7	157	60
8	96	120
9	63	97
10	60	103
11	28	68
12	63	46
13	89	102
14	112	79
15	96	115
16	65	85
17	102	108
18	109	168
19	63	38
20	105	69
21	88	98
22	60	90
23	46	84
24	78	66
25	145	198
26	67	76
27	100	210
28	93	117
29	117	155
30	75	96
Total	2682	3324
Mean	89.4	110.8

Scores were determined by the formula: $\frac{\text{repetitions X weight}}{100}$

APPENDIX P

INITIAL AND FINAL MUSCULAR ENDURANCE OF THE LEGS SCORES AS MEASURED IN THIS STUDY FOR GROUP III

Subjects	Initial Scores	Final Scores
1	110	86
2	98	104
3	81	196
4	26	78
5	102	107
6	92	143
7	97	80
8	78	79
9	105	122
10	85	176
11	60	92
12	41	64
13	24	92
14	88	175
15	77	41
16	146	204
17	131	137
18	82	111
19	59	62
20	135	184
21	82	65
22	96	192
23	62	52
24	134	194
25	73	64
26	63	75
27	46	87
28	90	53
29	76	111
30	91	72
Total	1929	3297
Mean	64.3	109.9

Scores were determined by the formula: $\frac{\text{repetitions X weight}}{100}$

APPENDIX Q

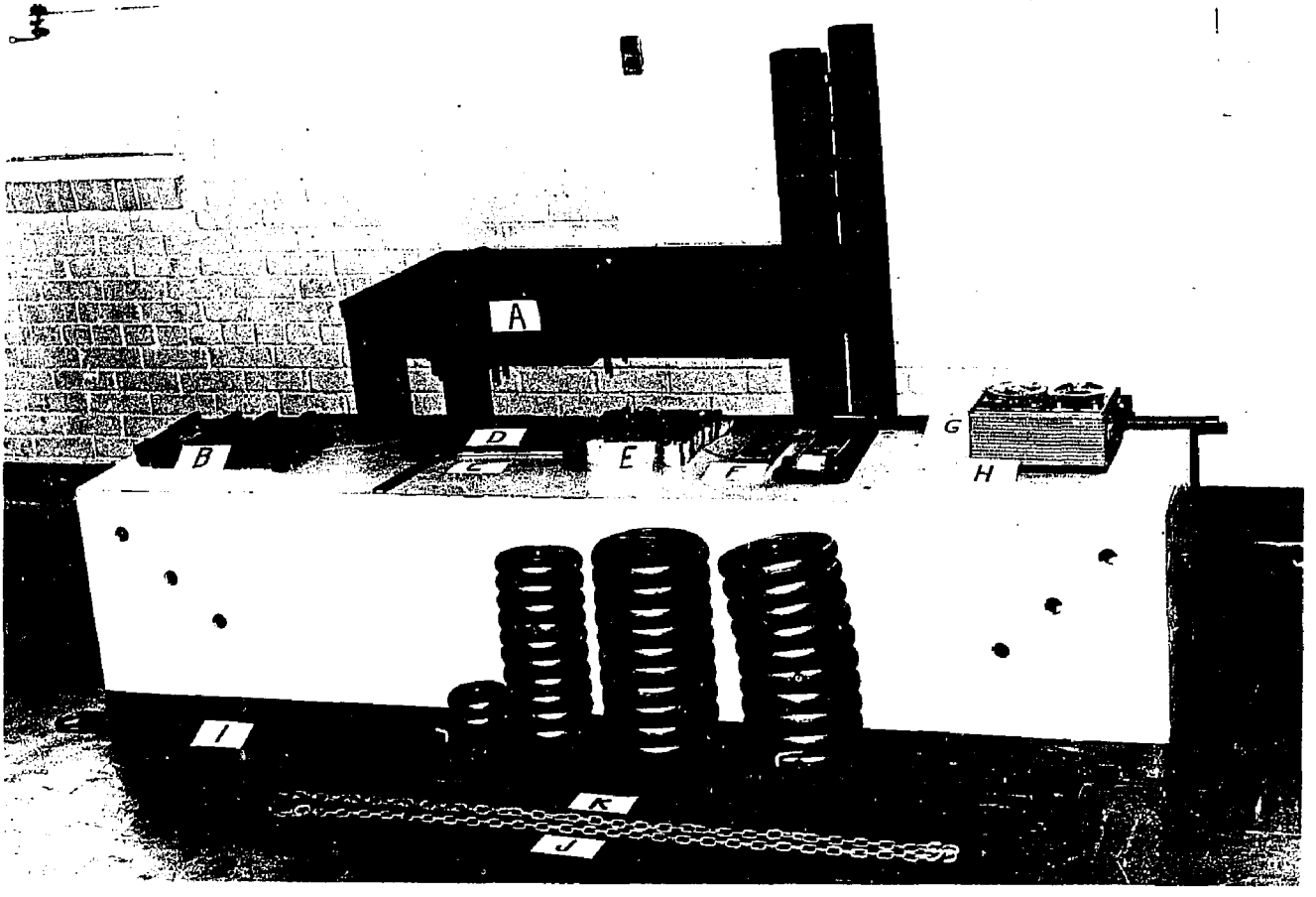
INITIAL AND FINAL MUSCULAR ENDURANCE OF THE LEGS SCORES AS MEASURED IN THIS STUDY FOR GROUP IV

Subjects	Initial Scores	Final Scores
1	76	86
2	48	86
3	60	81
4	71	75
5	84	72
6	78	105
7	98	84
8	96	93
9	115	99
10	161	146
11	78	85
12	104	125
13	58	104
14	59	67
15	108	125
16	38	130
17	77	137
18	129	88
19	126	88
20	38	37
21	71	67
22	79	117
23	68	54
24	75	56
25	41	132
26	31	81
27	70	86
28	68	108
29	73	128
30	71	65
Total	2349	2808
Mean	78.6	93.6

Scores were determined by the formula: $\frac{\text{repetitions X weight}}{100}$

APPENDIX R

TESTING AND TRAINING EQUIPMENT USED IN THIS STUDY



This picture shows the testing apparatus used in this study. The items are in alphabetical order: A - Testing Bench; B - Chocks; C - Goniometer; D - Strap and bar used for leg strength test; E - Isometric Straps; F - Iso-scales and aluminum mounting plate; G - Steel Bar; H - Tape Recorder; I - Padded Belt; J - Chains; K - Barbell and Weights. Items B through H are resting on the Step Test Bench.

VITA

The author was born in Ozark, Alabama on June 2, 1930. He attended the Dale County school system through junior high school and completed his high school education in New Orleans, Louisiana.

He received his Bachelor of Science degree from Auburn University, Auburn, Alabama, in 1953 with a major in Physical Education. The Master of Education degree was obtained at Auburn University in 1959.

The author has been employed by Auburn University, Auburn, Alabama; McCallie School, Chattanooga, Tennessee; and Andrew College, Cuthbert, Georgia. He was employed for two years (September, 1963 to August, 1965) as a Graduate Teaching Assistant in the Department of Health, Physical and Recreation Education at Louisiana State University while working toward the Degree of Doctor of Philosophy. For the past two years he was employed by Pembroke State College, Pembroke, North Carolina where he has been teaching in the Physical Education Department and coaching Soccer and Wrestling.

He is a member of the American Association for Health, Physical Education, and Recreation, The American Wrestling Coaches and Officials Association, the American Soccer Coaches Association.

The author has contributed a set of illustrated wrestling charts to professional publications in the field of Health, Physical Education and Recreation.

EXAMINATION AND THESIS REPORT

Candidate: Daniel P. McNair

Major Field: Physical Education

Title of Thesis: Effects of Different Exercise Programs on the Development of Cardiovascular Fitness, Strength and Muscular Endurance

Approved:

Jack K Nelson
Major Professor and Chairman

Max Goodrich
Dean of the Graduate School

EXAMINING COMMITTEE:

F A Drury

J B Keller

Jan Kistler

Evelyn G. Clark

Date of Examination:

July 11, 1967